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A Check List of the Families and Genera of North American Dinosaurs

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A CHECK LIST OF THE FAMILIES AND GENERA OF NORTH AMERICAN DINOSAURS

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ABSTRACT

The occurrence of 121 genera representing 34 families of Saurischian and Ornithischian dinosaurs is documented through approximately 150 million years of Mesozoic time in North America. The distribution of Triassic and Jurassic continental sediments restricts the known distribution of early Mesozoic dinosaurs, but during Cretaceous time dinosaurian remains have been recovered nearly to the limits of the continent, extending from latitude 15° to 70° North and from the Atlantic to the Pacific coasts. Indications are that the number of dinosaurian taxa recorded from North America will continue to rapidly increase well into the next century.

RESUME

L'existence de 121 genres de dinosaures, représentant 34 familles de Saurischiens et d'Ornithischiens, est attestée en ce qui concerne une période d'environ 150 millions d'années du Mésozoïque nord-américain. La répartition des sédiments continentaux du Trias et du Jurassique limite la répartition connue des dinosaures du Mésozoïque inférieur, alors que des restes de dinosaures remontant au Crétacé ont été découverts presque jusqu'aux limites du continent, de 15° à 70° de latitude nord et de la côte de l'Atlantique à celle du Pacifique. Tout porte à croire que le nombre de taxons de dinosaures découverts en Amérique du Nord continuera à croître rapidement jusqu'à une date avancée du XXI^{e} siècle.

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INTRODUCTION

Mesozoic strata in North America have yielded skeletal remains of two great orders of archosaurs, popularly known as dinosaurs (Saurischia and Ornithischia, for a classification see Appendix 1), in an abundance which has not thus far been equalled on other continents. In spite of a widespread interest in dinosaurs and the publication of many books and articles written for the lay public, the history of dinosaurian faunas on our continent has not been widely discussed in paleontological literature. Traditionally, the approach has been phylogenetic rather than faunistic. The changing importance of various dinosaurian groups through time is often represented by inflations or constrictions in bar graphs, the sides of which converge toward the points of entry into and disappearance from the stratigraphic record. A tabulation of dinosaurian genera and families was therefore made with the object of examining dinosaurian diversity trends through time (Figures 1, 2; Russell 1984). Not surprisingly, the fragmentary nature of our knowledge of dinosaurian faunal evolution became vividly evident. The results are herewith presented (Table 1) in the hope that they will stimulate corrections and additions from colleagues who are more familiar with the numerous segments of the dinosaurian record on our continent. In this manner our understanding of dinosaurian faunal evolution in North America may more rapidly advance.

THE RECORD OF NORTH AMERICAN DINOSAURS

Nearly ninety years years ago Marsh (1896) published a compilation of dinosaurian genera and families recognized at the time. His list includes 29 families and 62 genera from North America, about half of which are currently applied to taxonomically recognizable groups of dinosaurs. In 1961 Colbert listed 89 genera of North American dinosaurs, about two-thirds of which are currently considered valid. According to White (1973) 26 families are indicated by 83 genera (nearly 90% of which are now considered valid) based on North American type material. Thirty-four families and at least 121 genera are indicated in the present compilation, continuing a trend which suggests that numerous taxa remain to be discovered and described.

Many circumstances contribute to the incompleteness of our knowledge of North American dinosaurs. Only part of the continent has been, and to a large extent can ever be sampled, so that the ancient distributions of many taxa are not included in modern areas of exposed strata of the appropriate age. Exacerbating this difficulty is the possibility that some

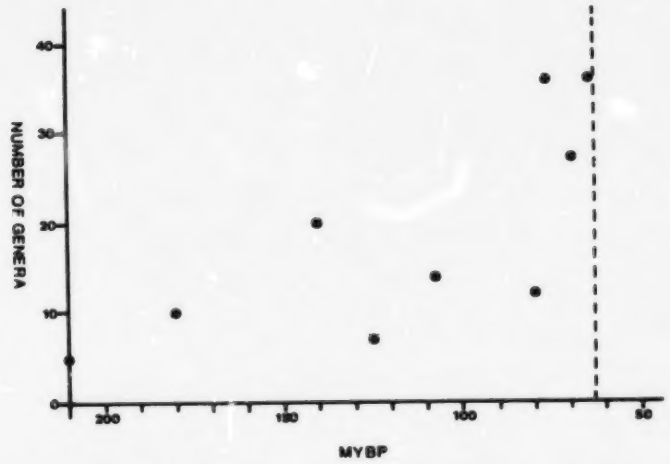

FIGURE 1: *Generic diversity of North American dinosaurs plotted against time measured in millions of years before the present (MYBP). The vertical line represents the Cretaceous-Tertiary boundary plotted at 63 MYBP.*

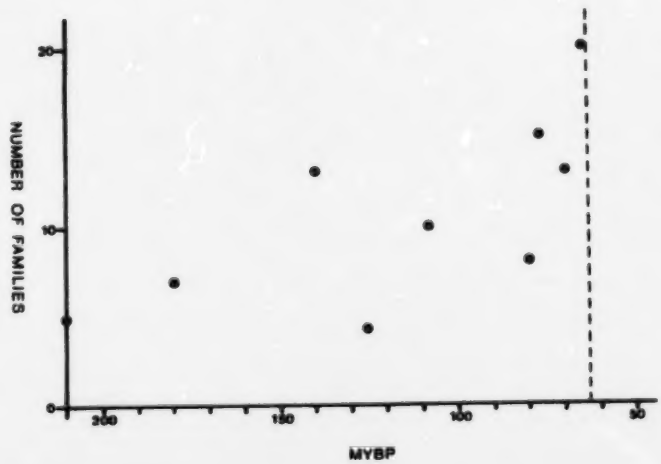

FIGURE 2: *Familial diversity of North American dinosaurs, plotted as in Figure 1.*

dinosaurian assemblages seem to be strongly affected by local environmental conditions, at least during late Cretaceous time (Lucas 1981, Russell 1982). Many assemblages have probably not been sampled to the extent of revealing the major part of their diversity (Figure 3). The persistence of dinosaurian taxa in time is poorly known. A 40 million-year lacuna occurs during the middle Jurassic; other gaps of about 20 million years duration occur in the late Triassic and early late Cretaceous, and only a few taxa of earliest Cretaceous age are known. As yet unknown dinosaurs are evidenced by footprints in the Passaic and equivalent formations of the Newark Group (Olsen 1980, p. 43, Figure 3.4L), the trackway of a colossal sauropod from the Dakota Formation of Colorado (E.G. Kauffman, personal communication 1983) and of a hadrosaur larger even than the giant *Shantungosaurus* of eastern China (Hu 1973), from the Mesaverde Formation of Colorado (Lockley *et al.* 1983).

The incompleteness of the fossil record is a problem with which all paleontologists are familiar. In the case of the dinosaurs of North America the situation is rendered more than usually severe by the small number of research positions (de Ricqlès 1971). Several major museums which house important collections of dinosaurs no longer support active research programmes centred on dinosaurian studies. Various recent controversies, for example on dinosaurian metabolism (Thomas and Olson 1980), intelligence (Hecht and Williams 1982), extinction (Silver and Schultz 1982) and relationship to birds (Ostrom 1976, Tarsitano and Hecht 1980, Jensen 1981A, 1981B; Lewin 1983), have occupied a significant part of the available research effort to the detriment of taxonomic studies. It is to be hoped that public interest in dinosaurs, as well as a concept of the dinosaurian world as an alternative experiment in the evolution of complex life on our planet (Russell 1983A, 1983B), will generate increased support for dinosaurian research in the future.

The oldest skeletal material referrable to dinosaurs from North America occurs in strata of Carnian or early late Triassic age, here considered as dating from approximately 210 million years ago. Staurikosaurids (Saurischia) and hypsilophodontids (Ornithischia) are known from sediments of Ladinian-Carnian age, or probably a few million years older in South America (Galton 1977A, Colbert 1981, Bonaparte 1982). No earlier records of dinosaurs have yet been documented, although the two orders are quite distinct in latest middle Triassic time. Dinosaurs disappeared in a global extinction event which occurred approximately 63 million years ago (Baadsgaard and Lerbekmo 1980) at the end of Cretaceous (Maastrichtian) time. Their temporal distribution thus extended for nearly 150 million years on this

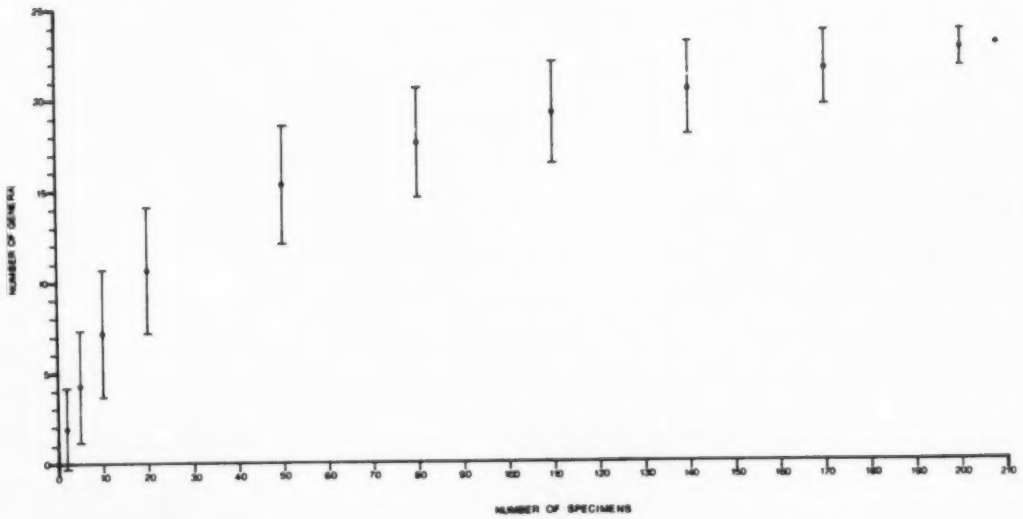

FIGURE 3: *A rarefaction curve with 95% confidence limits plotted for 208 specimens separated into 23 generic categories from Dinosaur Provincial Park, Alberta (~ 76 MYBP). To illustrate the meaning of the curve, subsamples of 50 specimens would contain an average of approximately 15 genera, and 95% of the subsamples would contain approximately 12 to 19 genera. The curve was generously provided by D.M. Raup of the University of Chicago; for a discussion of rarefaction methodology see Tipper (1979).*

continent. The Mesozoic Era ("Age of Reptiles") may not be regarded as synonymous with the age of dinosaurian ascendancy. Mesozoic terrestrial faunas have recently been grouped into four to five major epochs ("Dynasties" of Bakker 1977; "Empires" of Anderson and Cruikshank 1978, Benton 1983), the earliest of which are dominated by rhynchosaurs, therapsids and pseudosuchians instead of dinosaurs. A major faunal change occurred near the end of Triassic time when these three groups were rapidly and completely replaced by ornithischian and saurischian dinosaurs (Benton 1983). An abrupt extinction event also occurred at the end of the Triassic Period in marine environments (Tozer 1971A, 1971B; Hallam 1981, Raup and Sepkoski 1982). It would be tempting to ascribe the biotic changes in the two environments to a common cause. At this writing, our understanding of this terminal Triassic extinction interval appears comparable to our understanding of the marine and terrestrial extinctions at the Cretaceous-Tertiary boundary as of two decades ago.

The early Jurassic age of several assemblages, the existence of which has long been known, has only recently been recognized (Olsen and Galton 1977, Olsen 1980, Olsen and Baird 1982, Olsen *et al.* 1982). The faunas seem to have been dominated by prosauropods, primitive theropods and small ornithopods which were closely related (often on a generic level) to forms in Europe, Asia, South America and Africa (Galton and Cluver 1976, Colbert 1981, Chatterjee 1983, Attridge *et al.* in press). The famous sauropod dominated faunas of late Jurassic age (Dodson *et al.* 1980) contain many genera which occur in western Europe and east Africa in strata of about the same age (Galton 1977B, 1982). Peculiar long-spined forms (Dalton Well fauna, Utah) and truly gigantic sauropods (Dry Mesa fauna, western Colorado) have recently been excavated from transitional Jurassic-Cretaceous strata in the Rocky Mountain states (Jensen 1979, 1983; and Jensen in Ostrom 1978B). An inventory of quarried materials now being prepared by Jensen (personal communication 1983) will probably reveal the presence of previously unknown dinosaurian taxa.

Early Cretaceous faunas from the interior of the United States appear to be characterized by an abundance of nodosaurids. These animals are unknown in well-sampled late Jurassic sediments in North America but occur in middle and late Jurassic strata in western Europe (Galton 1981). Fragmentary remains of European ornithopod genera are also tentatively recognized in sedimentary units containing nodosaurids (Galton and Jensen 1975). Curiously, large four-toed hypsilophodontids are well represented by skeletal remains but not in trackways, whereas three-toed iguanodontid-hadrosaurid trackways are common but the latter

animals are poorly represented by skeletal material (Sternberg 1932, Langston 1974, Currie and Sarjeant 1979). The late Cretaceous dinosaur assemblages of North America are characterized by the great generic diversity of hadrosaurids and ceratopsids, although on a familial level saurischians continue to be more diversified. Some faunal affinities remain with Europe (e.g. Paris and Taquet 1973) and eastern Asia (e.g. Osmolska 1980), but sauropod dominated assemblages of the southern hemisphere late Cretaceous seem quite exotic by comparison (cf. Huene and Matley 1933, Lapparent 1960, McLachlan and McMillan 1976, Bonaparte 1978). The rifting apart and dispersal of the continents through Mesozoic time disrupted a relatively homogeneous terrestrial fauna and produced a continental biogeography as varied as that existing today.

Dinosaur remains are distributed broadly across the continent in terrestrial and shallow marine sediments. Occurrences of late Triassic - early Jurassic forms are scattered along a 4,500 km, southeastwardly-bowed arc extending from Arizona in the southwest (latitude 35°N, longitude 110°W) to Nova Scotia in the northeast (latitude 45°N, longitude 64°W, Jacobs and Murray 1980, Colbert 1981, Chatterjee 1983, Olsen 1980, Olsen and Baird 1982, Baird and Olsen 1983, Galton 1983A). It will be interesting to see if dinosaurian faunal differences can be documented which paralleled vegetational differences between the ends of the arc (Stone 1978). A vertebra (*Arctosaurus*) from late Triassic strata on Cameron Island in the Canadian Arctic Archipelago (latitude 77°N, longitude 104°W, Heiberg Formation, see Thorsteinsson and Tozer 1976), tentatively referred to the Theropoda by Galton and Cluver (1976), has more recently been considered as non-dinosaurian (trilophosaurid, D. Baird, personal communication 1983). Late Jurassic occurrences are confined to the area of outcrop of the Morrison Formation on the western high plains of the United States (Dodson *et al.* 1980, Figure 1).

The known distribution of Cretaceous dinosaur localities extends nearly to the limits of the present day land surface. Maastrichtian (terminal Cretaceous) occurrences are known from the Yukon Territory (hadrosaurid, latitude 66°N, longitude 135°W, see Appendix 2) and District of Mackenzie (ceratopsian, latitude 65°N, longitude 126°W, see Appendix 2). Hadrosaurid remains were also collected in proximity to a Cretaceous-Paleocene contact near the delta of the Colville River in northern Alaska (latitude 70°N, longitude 151°W, W. Langston, Jr. and C.A. Repenning, personal communication 1984). Ornithopod tracks and skin impressions of Aptian age have been recovered from the North Slope of Alaska (latitude 69°N, longitude 152°W, Chandler Formation, C.G. Mull and N. Hotton, personal communication 1983;

for stratigraphic setting see Ahlbrandt 1979).

Southerly occurrences of Cretaceous dinosaurs in the United States include localities in Big Bend National Park, Texas (latitude 29°N, longitude 103°W) where diversified assemblages are known from the Campanian Aguja Formation (Lehman 1982) and the Maastrichtian Javelina Formation (Lawson 1976). Mexican occurrences have been noted in the Sabinas Basin, Coahuila (latitude 28°N, longitude 101°W, a ceratopsian skeleton from Campanian-Maastrichtian continental strata, Wilson 1972, p. 163; for stratigraphic setting see McBride *et al.* 1974, pp. 1604-1605) and in the Parras Basin, Coahuila (latitude 26°N, longitude 101°W). In the latter region J.A. Wilson (in Murray *et al.* 1960, pp. 88-89, see also McBride *et al.* 1974, p. 1610) has identified hadrosaurid and ceratopsid remains in the late Campanian Cerro del Pueblo Formation, and with E.H. Colbert (in Murray *et al.* 1960, p. 90) identified ceratopsid material from the overlying early Maastrichtian Cerro Huerto Formation. I prospected this region over a period of two weeks in 1961 and found few bone-producing localities. In Baja California del Norte sediments of approximately the same age have yielded associated skeletal fragments (latitude 30°N, longitude 116°W, La Bocana Roja and El Gallo Formations, Morris 1973, Molnar 1974). Due to the combined effects of west coast strike-slip faulting (Dickenson 1983) and polar wandering these localities would have originally occupied a position several degrees further south. The most southerly occurrence of a North American late Cretaceous dinosaur is a hadrosaur from Honduras (latitude 15°N, Hotton 1980, p. 347; Weishampel and Weishampel 1983).

The most easterly occurrences of Cretaceous dinosaurs include those from the Albian-Aptian Arundel Formation of Maryland (latitude 39°N, longitude 77°W, Ostrom 1970, for stratigraphic setting see Hickey and Doyle 1977), and Campanian-Maastrichtian fluvial to shallow marine strata in North Carolina, Delaware and New Jersey (latitudes 35-40°N, longitudes 78-74°W, Baird and Horner 1979, Horner 1979). The situation on the west coast is less straightforward owing to the accretion of large portions of the western Cordillera during the last 200 million years (Coney *et al.* 1980, Jones *et al.* 1982). Dinosaur remains of late Cretaceous age have been recovered from the Californias (Morris 1973), which by then were already joined to North America. Continental blocks from the central Pacific (cf. Tozer 1982) may well have been a source of exotic Mesozoic land biota. So far dinosaurian skeletal materials have not been recovered from pre-accretionary deposits on the formerly insular blocks, although ornithopod and theropod footprints have been observed in late Jurassic

strata near Meshik (Port Heiden) on the Alaska Peninsula (latitude 57°N; D. Baird, personal communication 1984). Thus dinosaurs did inhabit these terranes during late Cretaceous time (for a tectontically similar occurrence in New Zealand, see Molnar 1980).

There is little evidence for faunal subdivisions of a subcontinental scale in North America during the Cretaceous. In both middle and late Cretaceous time sauropods were apparently relatively more abundant in low latitudes (cf. Sternberg 1932, Ostrom 1970, Langston 1974, Lehman 1981). A few late Cretaceous genera, which seem to be relatively conspicuous elements of Atlantic coastal plain assemblages (*Dryptosaurus*, *Lophorothon*, see Carpenter 1982B) have not been identified in relatively well sampled assemblages in the western interior. Both Carpenter (1982B) and Baird (personal communication, 1984) have suggested that the absence thus far of ceratopsid records from the late Cretaceous of the Appalachian region is noteworthy. It is curious that ceratopsids, which were such a conspicuous element in North American faunas from the western interior and are so poorly represented in Asia (an orbital horn core from Uzbeck S.S.R., Rozhdestvensky personal communication 1970, also possibly cited by Maryanska and Osmolska 1975, p. 173; an epoccipital from Mongolia, Gilmore 1933 and Rowe *et al.* 1981), may have had a north-south distribution of nearly 5,000 km in North America. The occurrence in the District of Mackenzie (see above) is more than halfway from classic ceratopsid localities in southern Canada to the Asian landmass (see paleogeographic reconstructions in Cocks 1981).

A TABULATION OF GENERA AND FAMILIES

Table 1 lists families and genera of dinosaurs known from the Mesozoic of North America. The purpose of the compilation was to assess the number of different kinds of dinosaurs, based on skeletal remains, that existed in North America during successive intervals of the dinosaurian era. Hence only one definitive occurrence is cited for each generic category. In many instances (e.g. *Coelophysis*, *Anmosaurus*, *Camarasaurus*, *Tenontosaurus*, *Chasmosaurus*, *Edmontosaurus*, *Triceratops*) the genus has been recorded at other localities which have not been cited. The "reference" and "lithologic unit" pertain only to the single, definitive occurrence. It should be noted that several genera (*Aublysodon*, *Paronychodon*, *Pectinodon*) are known only from isolated teeth, which in dinosaurs do not generally provide as satisfactory a morpholcgical basis for generic identifications as they do in the case of mammals. Many genera are listed as "undetermined" or "undescribed." In the former case the genus is taken

as evidence of the presence of the family with which it is associated; the "undescribed" genera are evidence of the existence of new taxa which have been recognized and are in the process of being described. The genera *Labocania* and *Hypsibema* may belong to undefined family groups, and a third family group is now in the process of being defined (Brett-Surman, personal communication 1983).

Information on the stratigraphic position of a particular lithologic unit can often be found in geologic atlases of western North America (McCrossan and Glaister 1966, Mallory 1972) or in the cited reference. The biostratigraphic intervals into which dinosaurian taxa are grouped are approximately defined by the associated international marine stages. Mean dates for the intervals are after Obradovich and Cobban (1975), Van Hinte (1976A, 1976B) and Van Eysinga (1975, for an alternate time scale see Harland *et al.* 1982). Continental stage names or "North American Provincial Ages" have been founded upon some middle and late Cretaceous assemblages (Russell 1975), and these are given in parenthesis following the marine stage names. It will be evident that the process of grouping taxa into gross chronological subdivisions necessarily obscures finer scale temporal and ecological differences between local faunas. Abbreviations preceding specimen numbers include AM (Amherst College Museum), CM (Carnegie Museum of Natural History), NMC (Paleobiology Division, National Museums of Canada), UA (University of Alberta Paleontological Collections), UCMP (University of California, Berkeley, Museum of Paleontology) and YPM (Yale Peabody Museum).

I would be most grateful for, and cordially solicit written or oral communication concerning this compilation. If a viable need were thereby fulfilled the compilation could be revised and republished periodically.

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TABLE 1. *COMPILATION OF NORTH AMERICAN GENERA AND FAMILIES OF DINOSAURS.*

GEOLOGICAL AGE AND FAMILY	GENUS	REFERENCE	HORIZON
Triassic - Carnian - ~210 MY			
Podokesauridae	*Coelophysis*	Colbert 1972	Chinle Formation
	Undescribed genus	Long, pers. comm. 1983	Chinle Formation
Staurikosauridae	Undescribed genus	Long, pers. comm. 1983	Dockum Formation
Plateosauridae	Undetermined genus	Carroll *et al.* 1972, Galton, pers. comm. 1983, Long, pers. comm. 1983	Wolfville Formation
Fabrosauridae	Undetermined genus	Jacobs & Murray 1980, Galton, pers. comm. 1983	Chinle Formation
Hypsilophodontidae	Undescribed genus	Galton 1983A, Galton, pers. comm. 1983	New Oxford Formation
Jurassic - Hettangian-Pleinsbachian - ~180 MY			
Anchisauridae	*Anchisaurus*	Olsen 1980	Portland Formation
Plateosauridae	*Ammosaurus*	Olsen 1980	Portland Formation
	Massospondylus	Attridge *et al.* in press	Kayenta Formation
Segisauridae	*Segisaurus*	Olsen & Galton 1977	Navajo Sandstone
Podokesauridae	*Podokesaurus*	Olsen 1980	Portland Formation
	Dilophosaurus	Olsen & Galton 1977	Kayenta Formation
	Undescribed genus	T. Rowe, pers. comm. 1984	Kayenta Formation
Undetermined family	Undescribed genus (large)	Long, pers. comm. 1983	Kayenta Formation
Fabrosauridae	*Scutellosaurus*	Colbert 1981	Kayenta Formation
Heterodontosauridae	Undetermined genus	A.W. Crompton, pers. comm. 1984	Kayenta Formation
Jurassic - Kimmeridgian-Portlandian - ~140 MY			
Coeluridae	*Coelurus*	Ostrom 1980	Morrison Formation
	Ornitholestes	Ostrom 1980	Morrison Formation
Megalosauridae	*Marshosaurus*	Dodson *et al.* 1980	Morrison Formation
	Stokesosaurus	Galton 1976, Galton & Jensen 1979B	Morrison Formation
	Torvosaurus	Galton & Jensen 1979B	Morrison Formation
Ceratosauridae	*Ceratosaurus*	Dodson *et al.* 1980	Morrison Formation
Allosauridae	*Allosaurus*	Dodson *et al.* 1980	Morrison Formation
Ornithomimidae	*Elaphrosaurus*	Galton 1982	Morrison Formation
Cetiosauridae	*Haplocanthosaurus*	Dodson *et al.* 1980	Morrison Formation
Brachiosauridae	*Brachiosaurus*	Dodson *et al.* 1980	Morrison Formation
Camarasauridae	*Camarasaurus*	Dodson *et al.* 1980	Morrison Formation

Diplodocidae	*Apatosaurus*	Dodson *et al.* 1980	Morrison Formation
	Barosaurus	Dodson *et al.* 1980	Morrison Formation
	Diplodocus	Dodson *et al.* 1980	Morrison Formation
Fabrosauridae	*Echinodon*	Galton, pers. comm. 1983	Morrison Formation
Hypsilophodontidae	*Dryosaurus*	Galton 1983B	Morrison Formation
	Nanosaurus	Galton 1983B	Morrison Formation
	Othnielia	Galton 1983B	Morrison Formation
Iguanodontidae	*Camptosaurus*	Dodson *et al.* 1980	Morrison Formation
Stegosauridae	*Stegosaurus*	Dodson *et al.* 1980	Morrison Formation
Cretaceous - Valanginian - ∿125 MY			
Iguanodontidae	*"Camptosaurus"*	Galton & Jensen 1979A, P. Bjork, pers. comm. 1984	Lakota Formation
	?Iguanodon	Galton & Jensen 1979A, Charig 1980	Cedar Mountain Formation
Hypsilophodontidae	*?Hypsilophodon*	Galton & Jensen 1979A, Charig 1980	Lakota Formation
	Tenontosaurus	Weishampel & Weishampel 1983, Madsen, pers. comm. 1984	Cedar Mountain Formation
Hadrosauridae	Undetermined genus	Galton & Jensen 1979A	Cedar Mountain Formation
Nodosauridae	*Hoplitosaurus*	Galton & Jensen 1979A, Coombs 1978	Lakota Formation
	Sauropelta	Bodily 1969, Coombs 1978	Cedar Mountain Formation
Cretaceous - Aptian-Albian (Paluxian) - ∿108 MY			
Dromaeosauridae	*Deinonychus*	Ostrom 1969	Cloverly Formation
Caenagnathidae	*Microvenator*	Ostrom 1970	Cloverly Formation
Ornithomimidae	*Archaeornithomimus*	Ostrom 1970, Russell 1972	Cloverly, Arundel Formations
Megalosauridae	*Acrocanthosaurus*	Langston 1974	Antlers Sandstone
	Undetermined genus	Ostrom 1970	Cloverly Formation
Brachiosauridae	*Astrodon*	Langston 1974, McIntosh, pers. comm. 1983	Comanche Series, Arundel Formation
Titanosauridae	Undetermined genus	Ostrom 1970, McIntosh, pers. comm. 1983	Cloverly Formation
Fabrosauridae	Undetermined genus	Langston 1974, Galton & Jensen 1979A	Paluxy Formation
Hypsilophodontidae	*Tenontosaurus*	Ostrom 1970, Langston 1974	Cloverly Formation, Comanche Series
	Zephyrosaurus	Sues 1980	Cloverly Formation
Hadrosauridae	Undetermined genus	Galton & Jensen 1979A	Dakota Sandstone

TABLE 1. (Cont'd)

GEOLOGICAL AGE AND FAMILY	GENUS	REFERENCE	HORIZON
Nodosauridae	*Nodosaurus*	Ostrom 1970	?Dakota Sandstone
	Sauropelta	Ostrom 1970	Cloverly Formation
	Silvisaurus	Eaton 1960	Dakota Sandstone
Cretaceous - Cenomanian - ∿92 MY			
Hadrosauridae	Undetermined genus	Weishampel & Weishampel 1983	Valle de Angeles Redbeds (Honduras)
Cretaceous - Santonian - ∿83 MY			
Hadrosauridae	Hadrosaurinae, Undetermined genus	Horner 1979	Eutaw Formation
Cretaceous - Campanian (Aquilan) - ∿80 MY			
Dromaeosauridae	Undetermined genus	Russell 1972	Milk River Formation
	Paronychodon	Fox 1972	Milk River Formation
Undetermined family	*Labocania*	Molnar 1974	La Bocana Roja Formation
Tyrannosauridae	Undetermined genus	Russell 1964	Milk River Formation
Hypsilophodontidae	*"Laosaurus"*	Russell 1949, Galton 1973	Allison Formation
Pachycephalosauridae	*Stegoceras*	Russell 1964	Milk River Formation
Hadrosauridae	*Claoeaurus*	Horner 1979	Niobrara Chalk
	Lophorothon	Langston 1960	Mooreville Chalk
	Undescribed genus	Horner 1983	Two Medicine Formation
	Hadrosaurus	Baird & Horner 1977	Woodbury Formation
Ceratopsidae	Undetermined genus	Russell 1964	Milk River Formation
Nodosauridae	*Nodosaurus*	Horner 1979	Niobrara Chalk
Cretaceous - Campanian (Judithian) - ∿76 MY			
Dromaeosauridae	*Dromaeosaurus*	Colbert & Russell 1969	Oldman Formation
	Paronychodon	Sahni 1972, see Appendix 2	Judith River Formation
	Saurornitholestes	Sues 1978	Oldman Formation
Saurornithoididae	*Stenonychosaurus*	Russell 1969	Oldman Formation
Caenagnathidae	*Macrophalangia*	Osmolska 1976, 1981	Oldman Formation

Ornithomimidae	*Dromiceiomimus*	Russell 1972	Oldman Formation
	cf. *Ornithomimus*	Russell 1972	Oldman Formation
	Struthiomimus	Russell 1972	Oldman Formation
Aublysodontidae	cf. *Aublysodon*	Carpenter 1982A	Judith River Formation
Tyrannosauridae	*Albertosaurus*	Russell 1970	Oldman Formation
	Daspletosaurus	Russell 1970	Oldman Formation
Undetermined family	*Hypsibema*	Baird & Horner 1979	Black Creek Formation
Hypsilophodontidae	Undetermined genus	Sahni 1972, Galton, pers. comm. 1983	Judith River Formation
Fabrosauridae	Undetermined genus	Weishampel & Weishampel 1983, Galton, pers. comm. 1983	Judith River Formation
Hadrosauridae	*Brachylophosaurus*	Béland & Russell 1978	Oldman Formation
	Corythosaurus	Béland & Russell 1978	Oldman Formation
	Hadrosaurus	Horner 1983, Béland & Russell 1978	Oldman Formation
	Lambeosaurus	Béland & Russell 1978	Oldman Formation
	Maiasaura	Horner 1983	Two Medicine Formation
	Parasaurolophus	Béland & Russell 1978	Oldman Formation
	Prosaurolophus	Béland & Russell 1978	Oldman Formation
Pachycephalosauridae	*Gravitholus*	Wall & Galton 1979	Oldman Formation
	Ornatotholus	Galton & Sues 1983	Oldman Formation
	Pachycephalosaurus	Wall & Galton 1979	Oldman Formation
	Stegoceras	Wall & Galton 1979	Oldman Formation
Protoceratopsidae	cf. *Protoceratops*	Gilmore 1939, Sternberg 1951	Two Medicine Formation
Ceratopsidae	*Anchiceratops*	Langston 1959	Oldman Formation
	Centrosaurus	Béland & Russell 1978	Oldman Formation
	Chasmosaurus	Béland & Russell 1978	Oldman Formation
	Eoceratops	Tyson 1981	Oldman Formation
	Monoclonius	Béland & Russell 1978	Oldman Formation
	cf. *Pachyrhinosaurus*	Langston 1975	Two Medicine Formation
	Styracosaurus	Béland & Russell 1978	Oldman Formation
Nodosauridae	*Paleoscincus*	Carpenter, pers. comm. 1983	Oldman Formation
	Panoplosaurus	Coombs 1971	Oldman Formation
Ankylosauridae	*Euoplocephalus*	Coombs 1971	Oldman Formation

Cretaceous - Campano-Maastrichtian (Edmontonian) - ~70 MY

Dromaeosauridae	cf. *Dromaeosaurus*	Russell 1969	Horseshoe Canyon Formation
	Paronychodon	Armstrong-Ziegler 1978	Fruitland Formation
Saurornithoididae	cf. *Stenonychosaurus*	Russell 1969	Horseshoe Canyon Formation
Caenagnathidae	cf. *Macrophalangia*	NMC 9570, see Appendix 2	Horseshoe Canyon Formation
Ornithomimidae	*Dromiceiomimus*	Russell 1972	Horseshoe Canyon Formation

TABLE 1. (Cont'd)

GEOLOGICAL AGE AND FAMILY	GENUS	REFERENCE	HORIZON
	cf. *Ornithomimus*	Russell 1972	Horseshoe Canyon Formation
	Struthiomimus	Russell 1972	Horseshoe Canyon Formation
Tyrannosauridae	*Albertosaurus*	Russell 1970	Horseshoe Canyon Formation
	Daspletosaurus	Russell 1970	Horseshoe Canyon Formation
Undetermined family	*Hypsibema*	Baird & Horner 1979	Ripley Formation
Hypsilophodontidae	*Parksosaurus*	Galton 1973	Horseshoe Canyon Formation
Hadrosauridae	*Edmontosaurus*	Russell & Chamney 1967	Horseshoe Canyon Formation
	Hadrosaurus	Lucas 1981	Fruitland-Kirtland Formations
	Hypacrosaurus	Russell & Chamney 1967	Horseshoe Canyon Formation
	Lambeosaurus	Morris 1973, Horner 1979	El Gallo Formation, Bearpaw Shale
	Parasaurolophus	Lucas 1981	Fruitland-Kirtland Formations
	Saurolophus	Russell & Chamney 1967	Horseshoe Canyon Formation
Pachycephalosauridae	*Stegoceras*	Wall & Galton 1979	Horseshoe Canyon Formation
Protoceratopsidae	*Montanoceratops*	Sternberg 1951	St. Mary River Formation
Ceratopsidae	*Anchiceratops*	Russell & Chamney 1967	Horseshoe Canyon Formation
	Arrhinoceratops	Tyson 1981	Horseshoe Canyon Formation
	Chasmosaurus	Lucas 1981	Kirtland Formation
	Monoclonius	Lucas 1981	Fruitland Formation
	Pachyrhinosaurus	Langston 1975	St. Mary River Formation
	Pentaceratops	Lucas 1981	Fruitland-Kirtland Formations
Nodosauridae	*Panoplosaurus*	Coombs 1971	Horseshoe Canyon Formation
Ankylosauridae	*Euoplocephalus*	Coombs 1971	Horseshoe Canyon Formation
Cretaceous - Late Maastrichtian (Lancian) - ~64 MY			
Dromaeosauridae	cf. *Dromaeosaurus*	Ostrom 1969, Carpenter 1982A	Lance Formation, Hell Creek Formation
	Paronychodon	Carpenter 1982A	Hell Creek Formation
Saurornithoididae	*Pectinodon*	Carpenter 1982A	Lance Formation
	Stenonychosaurus	Carpenter 1982A	Lance Formation
Caenagnathidae	cf. *Macrophalangia*	Long & Russell (in prep.)	Hell Creek Formation
Undescribed family	Undescribed genus	Brett-Surman (in prep.)	Hell Creek Formation
Ornithomimidae	*Ornithomimus*	De Courten & Russell (in prep.)	Kaiparowits Formation
	Undescribed genus	Long & Russell (in prep.)	Hell Creek Formation
cf. Aublysodontidae	"Jordan theropod"	Molnar 1978, see Appendix 2	Hell Creek Formation
Dryptosauridae	*Dryptosaurus*	Baird & Horner 1977	New Egypt Formation
Tyrannosauridae	?"*Albertosaurus*"	Gilmore 1946B	Hell Creek Formation

	Dynamosaurus	Long & Russell (in prep.)	Hell Creek Formation
	Tyrannosaurus	Long & Russell (in prep.)	Hell Creek Formation
Titanosauridae	*Alamosaurus*	Gilmore 1946A	North Horn Formation
Diplodocidae	Undescribed genus	McIntosh, pers. comm. 1983, see Appendix 2	Lance Formation
Hypsilophodontidae	Undetermined genus	Galton in Sues 1980, p. 70	Lance Formation
Fabrosauridae	Undetermined genus	Weishampel & Weishampel 1983, Galton, pers. comm. 1983	Hell Creek Formation
Hadrosauridae	*"Anatosaurus"*	Brett-Surman 1979	Hell Creek Formation
	Edmontosaurus	Brett-Surman 1979	Hell Creek Formation
	Hadrosaurus	Lehman 1981	Naashoibito Member, Kirtland Formation
	Parasaurolophus	Weishampel & Jensen 1979	Kaiparowits Formation
	Saurolophus	Morris 1973	Moreno Formation
Thescelosauridae	*Thescelosaurus*	Galton 1974	Hell Creek Formation
	Undescribed genus	Galton, pers. comm. 1984	Hell Creek Formation
Iguanodontidae	Undetermined genus	McKenna 1980, Weishampel & Weishampel 1983, see Appendix 2	Harebell Formation
Pachycephalosauridae	*Pachycephalosaurus*	Wall & Galton 1979	Lance Formation
	Stegoceras	Wall & Galton 1979	Hell Creek Formation
	Stygimoloch	Galton & Sues 1983	Hell Creek Formation
Protoceratopsidae	*Leptoceratops*	Sternberg 1951, Ostrom 1978A	Scollard Formation, Lance Formation
Ceratopsidae	cf. *Chasmosaurus*	Long & Russell (in prep.)	Hell Creek Formation
	Diceratops	Hatcher *et al.* 1907	Lance Formation
	Pentaceratops	Lehman 1981	Naashoibito Member, Kirtland Formation
	Torosaurus	Tyson 1981	Lance Formation
	Triceratops	Hatcher *et al.* 1907	Lance Formation
Nodosauridae	*Paleoscincus*	Breithaupt 1982, Carpenter, pers. comm. 1983	Lance Formation
Ankylosauridae	*Ankylosaurus*	Coombs 1971	Hell Creek Formation

APPENDIX 1: *A CLASSIFICATION OF NORTH AMERICAN DINOSAURS.*

The following scheme is a conservative interpretation of the nomenclatural framework currently used in assessing the relationships of North American dinosaurs. Theropod infraorders are after Barsbold (1977), and ornithopod infraorders are in general accordance with subgroups proposed by Thulborn (1974, pp. 171-174) and Wall and Galton (1979, p. 1185). However the pachycephalosaurs are placed in a distinct suborder following Maryanska and Osmolska (1974). The number of genera occurring in North America in each family group is indicated in parentheses.

Order Saurischia

suborder uncertain (Galton 1977A)

Family Staurikosauridae (1 genus)

Suborder Theropoda

Infraorder Coelurosauria

Family Podokesauridae (5 genera)

Family Segisauridae (1 genus)

Family Coeluridae (2 genera)

undescribed family (Brett-Surman in preparation) (1 genus)

Infraorder Deinonychosauria

Family Dromaeosauridae (5 genera)

Family Saurornithoididae (2 genera)

Infraorder Carnosauria

Family Megalosauridae (6 genera)

Family Ceratosauridae (1 genus)

Family Allosauridae (1 genus)

Family Aublysodontidae (1 genus)

Family Dryptosauridae (1 genus)

Family Tyrannosauridae (5 genera)

undetermined family (*Labocania*)

Infraorder Ornithomimosauria

Family Ornithomimidae (6 genera)

Infraorder Oviraptorosauria

Family Caenagnathidae (2 genera)

Suborder Sauropodomorpha

Infraorder Prosauropoda

Family Anchisauridae (1 genus)

Family Plateosauridae (3 genera)

Infraorder Sauropoda

Family Cetiosauridae (1 genus)

Family Brachiosauridae (2 genera)

Family Camarasauridae	(1 genus)
Family Diplodocidae	(4 genera)
Family Titanosauridae	(2 genera)
undetermined family	(*Hypsibema*)
Order Ornithischia	
Suborder Ornithopoda	
Infraorder Hypsilophodontia	
Family Fabrosauridae	(5 genera)
Family Heterodontosauridae	(1 genus)
Family Hypsilophodontidae	(10 genera)
Infraorder Iguanodontia	
Family Thescelosauridae	(2 genera)
Family Iguanodontidae	(3 genera)
Family Hadrosauridae	(15 genera)
Suborder Pachycephalosauria	
Family Pachycephalosauridae	(5 genera)
Suborder Stegosauria	
Family Stegosauridae	(1 genus)
Suborder Ankylosauria	
Family Nodosauridae	(6 genera)
Family Ankylosauridae	(2 genera)
Suborder Ceratopsia	
Family Protoceratopsidae	(3 genera)
Family Ceratopsidae	(12 genera)

APPENDIX 2: *TERMINAL CRETACEOUS DINOSAUR SPECIMENS FROM NORTHERN CANADA WITH NOTES ON OTHER RECORDS.*

Hadrosauridae. UA 19363, distal caudal vertebra and fragments of fifth digit of manus (Figure 4). The locality (latitude 66°N, longitude 135°W), in the Maastrichtian portion of the Bonnet Plume Formation, Yukon Territory, is described in Rouse and Srivastava (1972) and the occurrence is cited by R.C. Fox in Hotton (1980, p. 347). The caudal vertebra is indistinguishable from distal caudals in CM 12100, a juvenile hadrosaurine from the Hell Creek Formation of Carter County, Montana. Fragments of two phalangiform ossifications closely resemble elements in the fifth digit of the manus in hadrosaurids (cf. Figure 4; Brown 1912, Figure 1; Parks 1920, Figure 13 and Plate 4, Figures 1, 2). The proportions of the latter structures are suggestive of an animal that had attained about one-half the linear dimensions of an adult *"Anatosaurus" annectens*.

length of centrum - 12 mm
width of centrum - 18 mm
height of centrum - 13 mm
maximum diameter, distal end of phalangiform ossification - 18 mm

Ceratopsian. NMC 38507, articular end of right quadrate (Figure 5) and broken ?frill fragments. The specimen was discovered by A.R. Sweet of the Geological Survey of Canada during the summer of 1983 in exposures near the headwaters of the East Little Bear River, Northwest Territories (latitude 64°33'20"N, longitude 125°49'45"W). The locality is in the Maastrichtian portion of the Summit Creek Formation, although the position of the Cretaceous-Tertiary boundary has not been precisely determined palynologically (A.R. Sweet, personal communication 1983). The regional stratigraphic setting is described in Yorath and Cook (1981).

The quadrate resembles those of ceratopsians in its straight, broad shaft and the solid lateral contact it evidently made with the quadratojugal. It was derived from an animal similar in size to ceratopsids from the Oldman (Judith River) Formation in southern Alberta (NMC 348, 2280, 8790, 8795, Table 2). The distal condyles have been somewhat abraded on the specimen but the general morphology of the articular surface resembles that in ceratopsid crania in the collections of the National Museum of Natural Sciences. However, the suture with the quadratojugal is unusual in that it does not extend medially around to the posterior

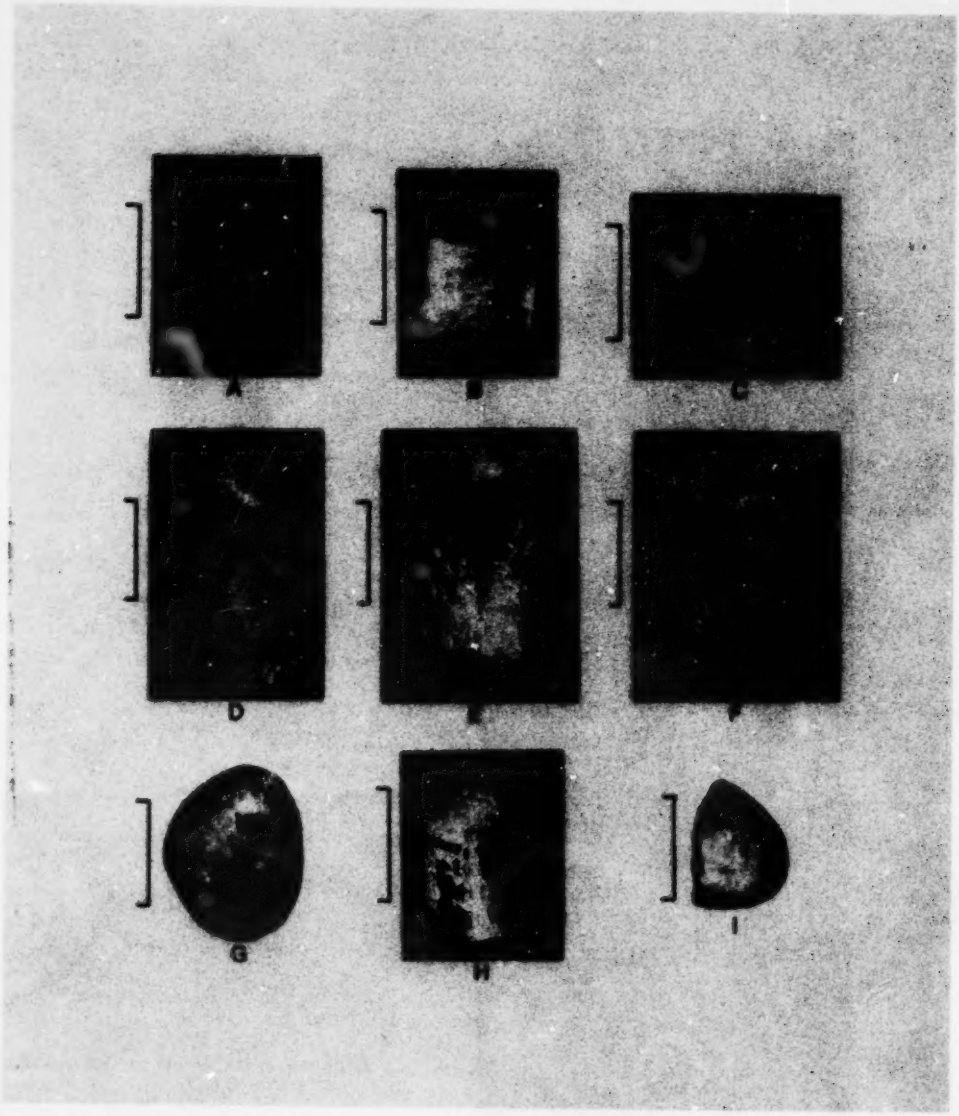

FIGURE 4: *Hadrosauridae, UA 19363, distal caudal vertebra and fragments of fifth digit of manus (A - caudal vertebra, dorsal aspect; B - caudal vertebra, left lateral aspect; C - caudal vertebra, anterior aspect; D-G - proximal phalanx digit five, various aspects; H-I - distal phalanx digit five, various aspects). Scale bar equals 1 cm.*

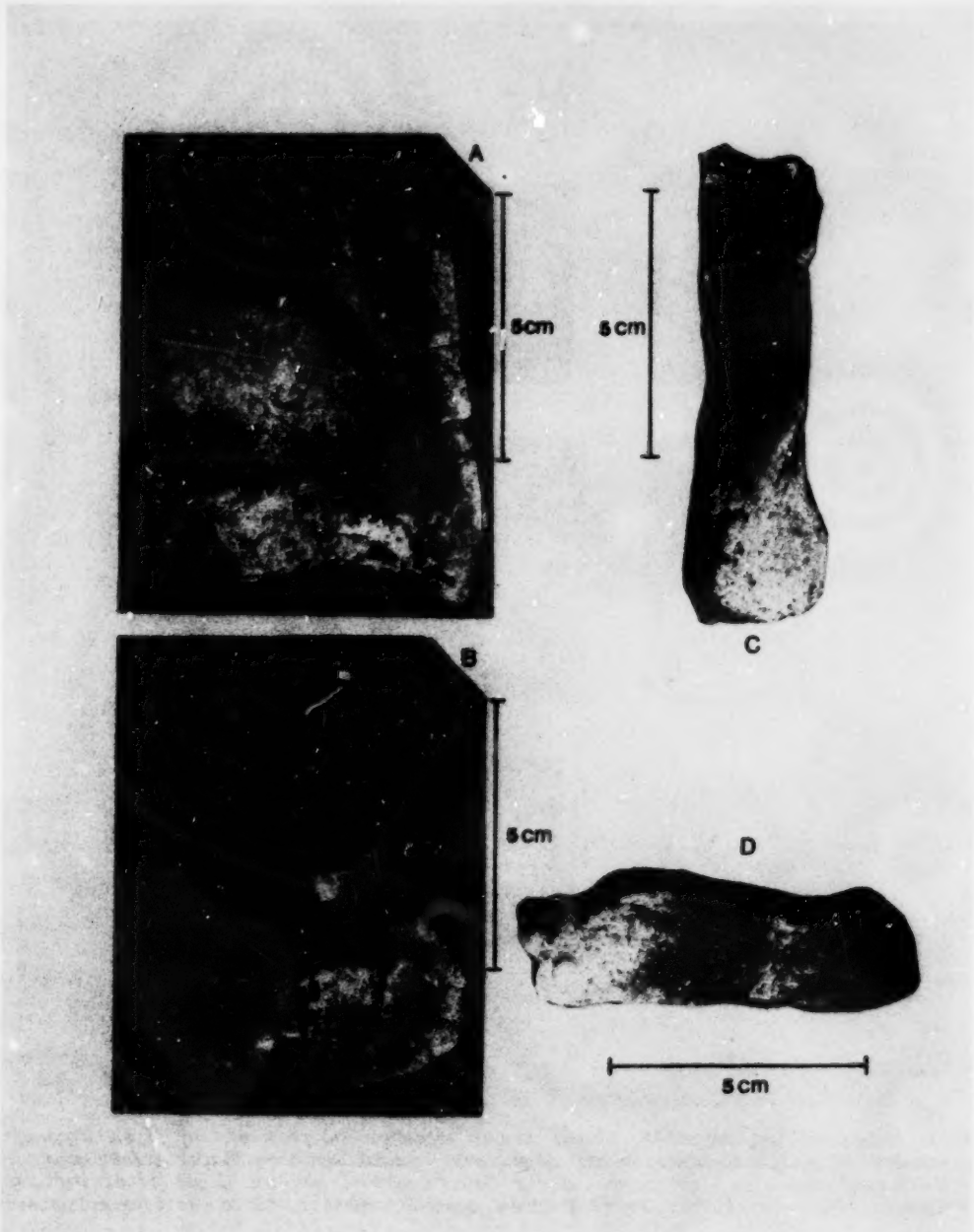

FIGURE 5: *Ceratopsian, NMC 38507 right quadrate (A - anterior aspect; B - posterior aspect; C - lateral aspect; D - ventral aspect, the anterior face is directed upwards).*

TABLE 2: *COMPARATIVE MEASUREMENTS OF THE QUADRATE IN THE CERATOPSIA.*

Family and Genus	Measurements (mm)	
	Transverse Length	Anteroposterior Width, Lateral Condyle
Psittacosauridae		
Psittacosaurus youngi Chao 1962, Figure 4, Plate 2, Figure 2	20	-
Protoceratopsidae		
Protoceratops andrewsi Brown and Schlaikjer 1940, Figure 16B	33	16
Leptoceratops gracilis NMC 8889	40	29
Ceratopsidae		
Monoclonius lowei NMC 8790	76	30
Chasmosaurus belli NMC 2280	84	29
Centrosaurus longirostris NMC 8795	84	37
Centrosaurus flexus NMC 348	85	33
Triceratops prorsus YPM 1822, Hatcher *et al.* 1907, Plates 33, 36	102	54
Pachyrhinosaurus canadensis NMC 9610	105	56
Summit Creek ceratopsian NMC 38507 (see Appendix 2)	~76	24

surface of the quadrate shaft to occupy a position above the lateral condyle (cf. Hatcher *et al.* 1907, Figure 26; and conditions in ceratopsid quadrates in Table 2). The quadratojugal suture is also separated from the articular surface laterally by a gap of about 20 mm, whereas in ceratopsids it appears to contact the articular surface. In *Leptoceratops* (NMC 8889) the suture with the quadratojugal resembles that of the Summit Creek ceratopsian in these respects, but differs in that the sutural surface is flat instead of longitudinally excavated into a V-shaped cleft. The familial affinities of NMC 38507 are uncertain.

Paronychodon. The jaws from the Oldman (Judith River) Formation of Alberta referred to *Chirostenotes* by C.W. Gilmore (1924, NMC 343) contain partially erupted teeth bearing 25 serrations per 5 mm on the posterior carina, which extend slightly over the apex of the tooth. The jaws are very elongated, resembling in this respect a frontal from the same local fauna (NMC 12355; Russell 1969, Sues 1978). The taxon possibly respresented by these remains might include isolated teeth referred to *Paronychodon*, although longitudinal crenulations are not visible on the poorly exposed crowns in NMC 343.

cf. *Macrophalangia*. A left second metatarsal (NMC 9570) was collected from the Horseshoe Canyon Formation as exposed on the west side of the Red Deer River opposite the mouth of Big Valley Creek in Alberta by C.M. Sternberg in 1926 (Figure 6). It has a small facet for articulation with a first metatarsal, which is located in a more distal position than in tyrannosaurids. It closely resembles the less well preserved second metatarsal in the type of *Macrophalangia canadensis* (NMC 8539). The specimen was referred to *Macrophalangia* in the records of the National Museum of Natural Sciences (Ottawa) by Wann Langston, Jr.

	NMC 8539	NMC 9570
Length	210	260
Proximal width	∿ 30	39
Distal width	∿ 24	26
Distal height	∿ 25	26

"Jordan theropod." The small theropod skull described by Molnar (1978) contains a "D"-shaped premaxillary tooth which lacks serrations on the carinae, as in the lectotype of *Aublysodon mirandus* (Carpenter 1982A). Another tooth described by Carpenter (UCMP 43447) resembles the first dentary tooth of the "Jordan theropod" (cf. Molnar 1978, Figure 5B).

Diplodocidae, undescribed genus. The left hind limb and foot of a diplodocid of moderate size is preserved in the collections of Amherst College Museum (AM 663). F.B. Loomis indicated in the museum records only that the specimen was collected from Lance Creek, Wyoming. The occurrence was cited by Sloan (1969) and disavowed by Lucas (1981, p. 377) and Baird (personal communication 1984). Matrix adhering to the specimen was removed and examined for fossil palynomorphs by R.G. Day of the National Museum of Natural Sciences (Ottawa), but was found to be barren. On the strength of Loomis' professional integrity and a morphology that departs somewhat from that of known Jurassic diplodocids (J.S. McIntosh, personal communication 1983) the occurrence of the form in the Lance Formation of Wyoming is provisionally accepted.

Iguanodontidae, undetermined genus. A tooth from the Harebell Formation of Wyoming was not relocated during my visit to the American Museum of Natural History in New York in 1984. It was not seen by Weishampel and Weishampel (personal communication 1984), and the record should be reconfirmed.

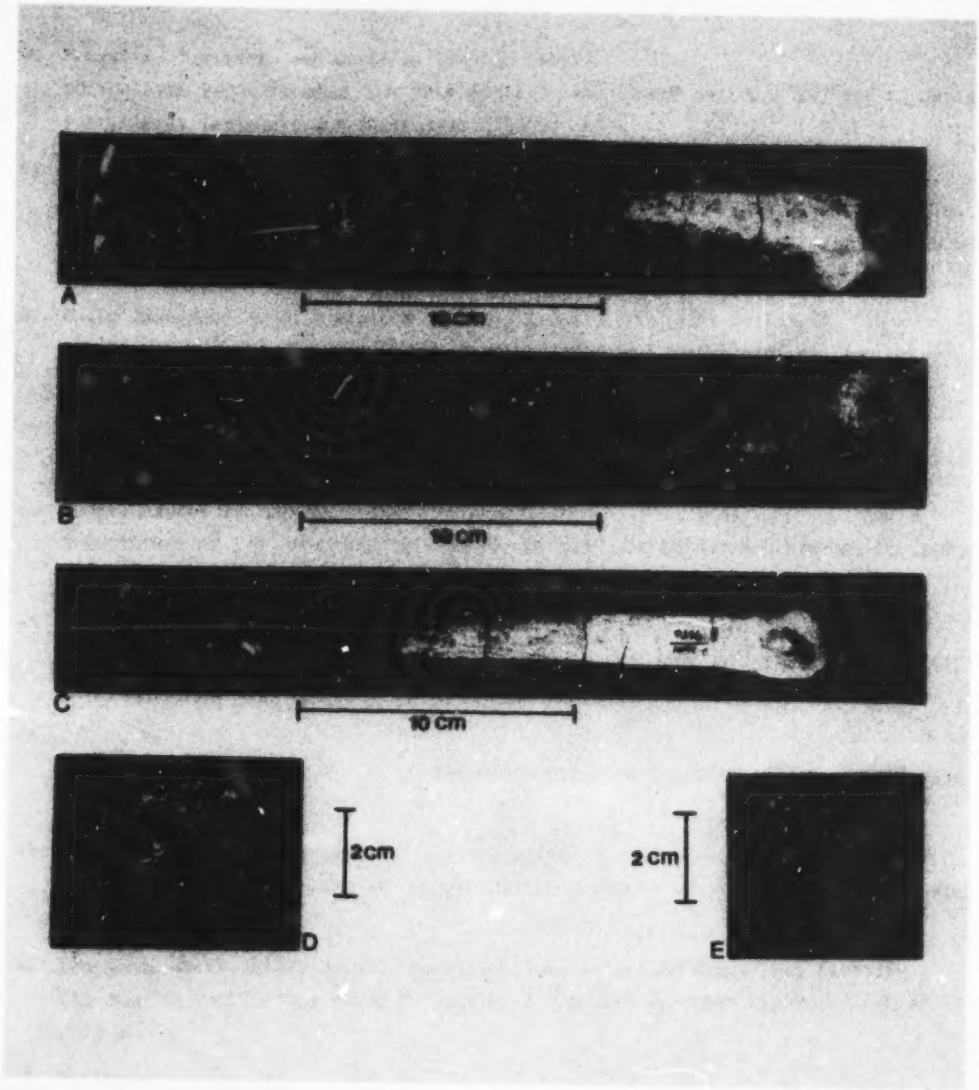

FIGURE 6: *cf.* Macrophalangia *sp., NMC 9570 left second metatarsal (A - anterointernal aspect; B - posterior aspect; C - lateral aspect; D - proximal aspect; E - distal aspect).*

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